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ABSTRACT

A lengthy and detailed description is given of a computer-based curriculum for initial reading, with emphasis on reading as decoding. The initial curriculum, prepared for a school in Cupertino, California, was closely linked to the three basal reading texts then being used in the district's primary classrooms and was programed as three separate series. A description of the hardware used and of the curriculum structure is given. A major evaluation has not yet been completed, but preliminary results showed gains by students who used the Computer Assisted Instruction (CAI) over those who did not use it and also more gains for boys than for girls in the CAI program. References are included. (NH)

COMPUTER-BASED INSTRUCTION IN READING: GRADES K-3

John D. Fletcher and R.C. Atkinson

Stanford University

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The Institute for Mathematical Studies in the Social Sciences (IMSSS) has for many years been actively involved in and contributed greatly to the rapid growth of computer-assisted instruction (CAI). With funds from the U.S. Office of Education and the Carnegie Foundation, the Institute has designed and implemented CAI programs in drill, tutorial and conversational modes of instruction. A variety of hardware configurations has been used in programs ranging from tutorial instruction in kindergarten and first-grade reading through second-language courses in Russian for college students.

The earliest effort, which began in 1965, was a drill-and-practice mathematics program. It used a time-sharing system on the PDP-Central Processing Unit at the Stanford Computation Center. In the beginning there was one terminal in a Cupertino, California, school. Today, programs operating off that PDP-1 system have grown from an original 41 students to more than 3,000 per day and cover, in addition to an expanded mathematics program, programs in spelling drill, Boolean algebra, logic, Russian, and a program for the teaching of computer programming. They are used throughout the United States. High-speed telephone wires provide the connection between the Stanford Computation Center and student terminal devices as far away as Mississippi and Washington, D.C.

The Stanford-Brentwood CAI Project began in the Ravenswood School District in 1965. Using the IBM 1500 System, computer-assisted instruction was provided in initial reading and first- and second-grade mathematics. Contributing to the design and production of these tutorial programs was a large project staff that included writers, mathematicians, artists, programmers, engineers, curriculum specialists and experienced elementary school teachers.

In 1968 the funding for the Stanford-Brentwood Project was shifted from Title 4 to Title 3 of the Elementary and Secondary Education Act. Cost factors necessitated changing from the IBM 1500 System to the current one which operates off a PDP-10 computer at the Stanford Computation Center. The Project has become a demonstration rather than a research program and the change has enabled a much larger student participation. As many as 1,400 students in the Ravenswood School District receive daily instruction in both reading and mathematics on 46 teletype terminals. Eighteen reading terminals with digitized audio are used by more than 400 students per day.

The Stanford-Brentwood CAI Laboratory has been in continuous operation since 1965. The original goal was to establish a laboratory for experimentation in basic learning theory in an on-going situation involving curriculum data. One of its most important characteristics is the possibility of conducting controlled experiments involving instructional materials.

RATIONALE

In the development of a computer-based curriculum for initial reading, a number of operational assumptions were made that should be explicated. The authors assumed, along with Bloomfield (1942), Carroll (1964), Fries (1963), and others, that two major aspects of reading are communication (reading for meaning, aesthetic empathy, enjoyment, etc.) and decoding. The communication aspect of reading seemed best presented in the classroom by a human teacher in some sort of dialogue mode, and the decoding aspect of reading seemed best presented by a computer in a consistent drill or practice mode. The major emphasis of this curriculum, then, is on reading as decoding.

Decoding may be defined as the rapid, if not automatic, association of phonemes or phoneme groups with their graphic representations; for example, the association of the phoneme /aeb/ with its graphic shape (or grapheme) ab, of the association of the phoneme /eyb/ with its graphic representation abe. It was assumed either that (a) learning to read necessitates learning a large repertoire of these "grapheme-phoneme" associations; or that (b) learning to read is significantly facilitated by acquiring a large number of these associations. Together with Fries (1963) and Ruddell (1966), the authors decided that it would be worthwhile to teach reading as decoding to initial readers.

Further assumptions were made about the appropriateness of computer-based presentation. Fries (1963, p. 132) stated that learning to make grapheme-phoneme associations was not only necessary for those learning to read, but that these associations must become habits so automatic that the graphic shapes themselves sink below the threshold of attention. An effective way for these associations to become automatic is by repetitive presentations for short intensive drill periods with the students given immediate knowledge of results after each of their responses. Such drill can be accomplished effectively at this time by an individualized computer-assisted drill program.

Since the emphasis in this program is on the regular grapheme-phoneme correspondences (or "spelling patterns") of English, the curriculum can be considered an appropriate adjunct to any classroom initial reading series. The initial curriculum, prepared in the fall of 1968, was closely linked to the three basal reading texts then being used in the district's primary classrooms and was programmed as three separate series. The reading curriculum currently used is based on the most frequently used vocabulary in major reading texts and sight-word lists which were scanned by utility computer programs for common occurrences and order of introduction.

THE COMPUTER-BASED READING PROGRAM

Student Terminal Description

Especially equipped Model 33 teletypes serve as student terminals for the reading program. Two major changes have been made in the standard model. First, audio capability, essential to initial reading instruction, enables the computer to communicate with the student by digitized audio messages played into a conventional headset. A headphone jack along with a simple, small-gain amplifier has been added to each of the Model 33 teletypes used by the reading curriculum.

The second modification of the Model 33 teletypes used by the Institute is the unique character set as illustrated in the keyboard layout depicted in Figure 1.

Curriculum Structure

Because the computer-assisted instruction in initial reading emphasizes the regular correspondence between spelling and sound which occurs in English orthography, it is a general program that can be keyed to any reading series. The Stanford-Ravenswood program is divided into six strands, with each strand providing exercise in an identifiable subskill of reading. The strands are: 0 - Machine Readiness; I - Letter Identification; II - Sight-Word Vocabulary; III - Phonics; IV - Spelling Patterns; and V - Comprehension.

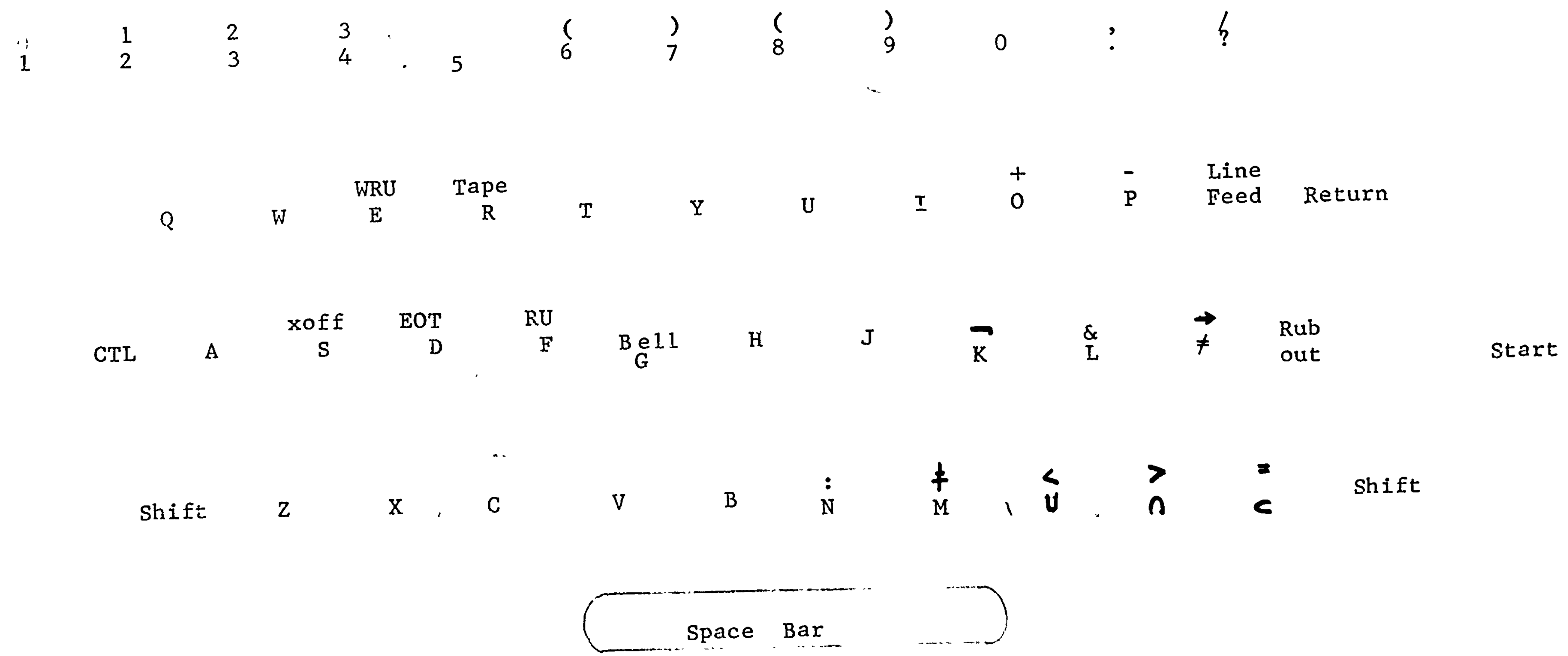

Figure 1. Standard IMSSS Keyboard

Used In Reading Program

The term strand is used in the reading program to define a basic component skill of initial reading. Students in the reading program move through each strand in a roughly linear fashion. Branching or progress within strands is criterion dependent; a student proceeds to a new exercise within a strand only after he has attained some (individually specifiable) performance criterion in his current exercise. Branching between the strands is time dependent; a student moves from one strand to take up where he left off in another after a certain (again, individually specifiable) amount of time regardless of what criterion levels he has reached in the strands. Within each strand there are 2-3 progressively more difficult exercises that are designed to bring students to fairly high levels of performance. The criterion procedure is explained in more detail in another section, but basically it involves two consecutive correct answers for each item and one errorless pass through the list of items constituting an exercise.

Entry into each strand is dependent upon a student's performance in earlier strands. For example, the letter-identification strand starts with a subset of letters used in the earliest sight words. When a student reaches a point in the letter-identification strand where he has exhibited mastery over the set of letters used in the first key words of the sight-word strand, he enters the sight-word strand. Entry into both the phonics and spelling pattern strands is controlled by the student's placement in the sight-word strand. Thus, a student may work in several strands simultaneously. Once he enters a strand, however, his advancement within that strand is independent of his progress in other strands. Figure 2 gives an overview of the reading program strand curriculum.

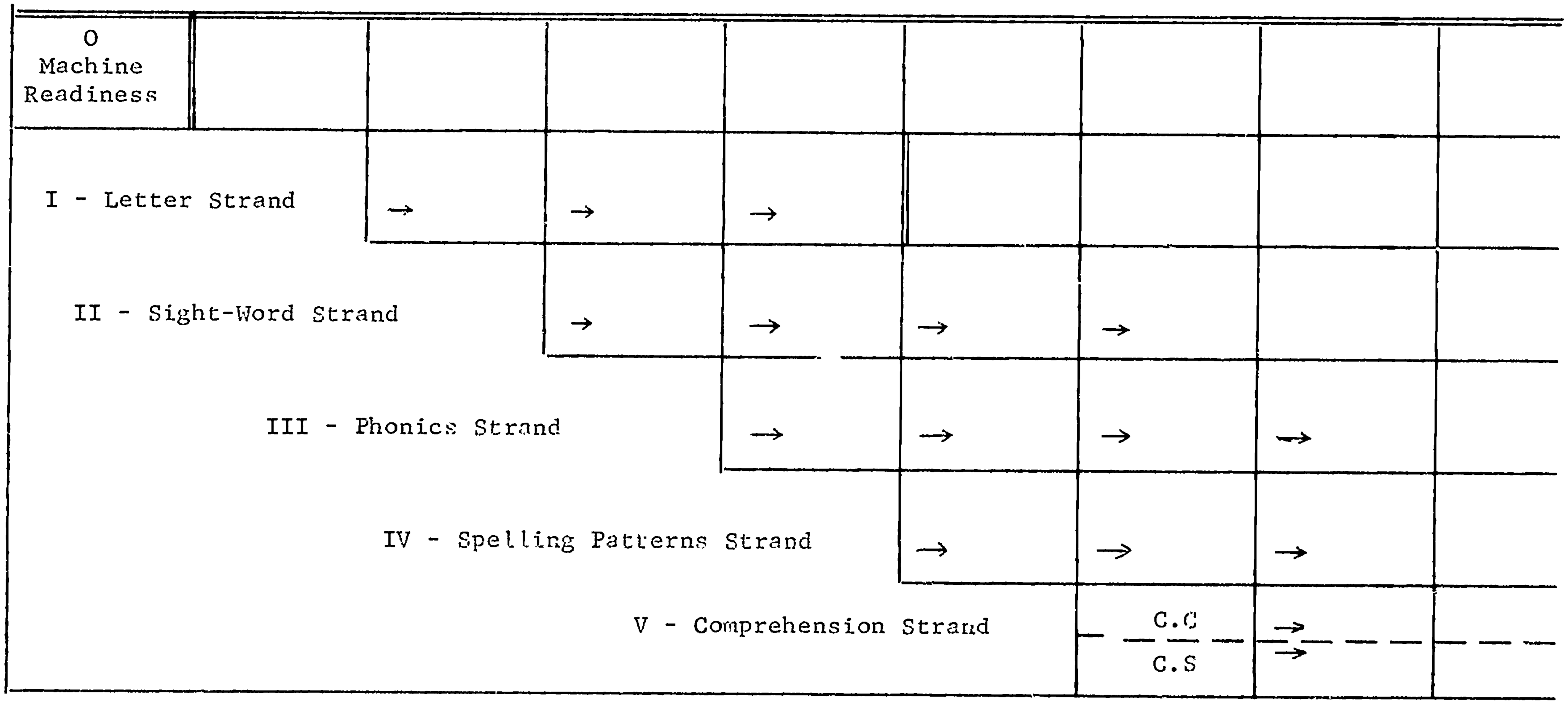

Figure 2. Overview of Strand Curriculum
Reading Program

Most students spend two minutes in each strand and the length of their daily sessions is eight minutes. The time each student spends in any strand and the length of the daily drill sessions are parameters that may be uniquely specified for individual students or particular classes. Sufficient information is saved in student restart records to assure continuation from precisely those conditions that existed at sign-off.

The strands are comprised of sections or sets of three curriculum items, and it is in these sections that a student must reach criterion before progressing in the strands. Each section is presented in either two or three separate exercises. In each exercise the three items of the section are presented in random order until the student has achieved a criterion, usually of two consecutive correct answers for each item and an errorless pass through the entire set. Thus, a student who already knows the material of a particular exercise may leave that exercise after only six responses, which may take him as little as 30 seconds.

Students receive instruction for the exercises by means of digitized audio messages. A vocabulary of approximately 5,000 sounds has been recorded and stored in digital form on the computer's magnetic disk. The student inputs his responses on the teletype keyboard. When he has completed his response, he presses the space bar which returns control of the terminal to the computer for response evaluation. If the student discovers an error in his response, he may press the rubout key before pressing the space bar and the entire problem will be presented again for a second trial. If a student presses the rubout key more than three times before entering a response, he receives a "too many rubouts" message. The student has a printed record of the work completed at the end of his session. Experience has shown that first-grade children adapt quickly to use of the keyboard and have no difficulty in typing the relatively short responses required.

Description of the Strands

Strand 0 - Machine Readiness. Readiness materials, designed both for the classroom and at the CAI terminal location, acquaint the student with the system and teach him the manual skills required to interact with the program. Following the terminal orientation section, the readiness strand attempts to teach students to sign themselves on the program without proctor supervision. To sign on the reading program, a student types R (for reading) and his assigned student number. He then types a space, follows with his first name, and another space. The program responds by typing the student's last name. If the last name is correct, the student types a space and the program proceeds with the student's individual lesson.

To teach this sign-on procedure, the format of each readiness response request is as follows:

Display	Audio
R	Type R

If the response is correct, the program plays "good" with a probability of .50, types the correct character and continues with the lesson. If the student's response is incorrect, the program plays "no, you typed..." followed by the name of the character the student typed, then "we wanted..." followed by the name of the correct character both in type and audio. The teletype repositions and types all the characters the student has entered correctly up to his last incorrect response and repeats the response request. An example of this would be:

Display		Audio
R213	JOH	Type N
R213	JOHM	No, you typed M
	N	We wanted N
R 213	JOH	Type N

To leave the readiness strand, a student must perform this sign-on procedure with no more than one error. The readiness strand differs from all the other strands in that branching from it is criterion dependent rather than time dependent.

Strand I - Letter Identification. The sequence of letters introduced in this strand is determined by the sight-word vocabulary in the early sections of Strand II. Each letter is presented twice in the letter strand. For the first pass through the alphabet, grouping of letters in three-letter sections was designed to minimize visual confusion. For the second pass through the alphabet, grouping was designed to maximize confusion. In all cases, sections were designed to minimize auditory confusion.

Three types of exercises are used throughout the letter-identification strand. In the first exercise, a letter is typed on the printout and the student is requested to type the same letter.

	Display	Audio
Ex. 1:		
	H	Type H

The exercise is repeated for another letter. Random presentation of the three letters in a section continues until the student reaches criterion for the first exercise, at which time he is advanced to the second exercise of the letter strand.

	Display	Audio
Ex. 2:	D H U	Type H

After each presentation, the order of the three letters in the display is randomly changed, and the exercise is repeated for another letter. Upon achieving criterion for each of the letters, the student proceeds to the third exercise.

	Display	Audio
Ex. 3:	(no display)	Type H

When the student achieves criterion on the three letters in the section in Exercise 3, he proceeds to the second set of three letters.

Throughout the curriculum, if the student responds correctly he proceeds to the next presentation. If he responds incorrectly or exceeds the time allowed for a response, the teletype displays the correct response and moves to the next presentation.

When the student responds correctly, he receives randomly scheduled audio reinforcement messages. The usefulness of "variable-interval reinforcement" has been well established as a method of achieving performance that is stable and highly resistant to extinction. In the beginning stages of program development these reinforcement messages consisted of ten commonly used positive words, but as the dictionary has been enlarged and more flexible utility programs written, it has become possible to include a greater variety of expressions. Programs now have reinforcement messages with words appropriate to season and locale, and jargon familiar to the children.

When a student meets criterion on a specific number of letters (i.e., those required for the first words in the sight-word vocabulary of Strand II), he begins Strand II. At this point, he works simultaneously in both Strands I and II, but at different levels of difficulty within each strand.

Strand II - Sight-Word Vocabulary. Strand II provides practice on a vocabulary that is introduced and taught in the classroom and contains words common to the major basal reading texts. The vocabulary is presented in sections of three words in two different exercises.

	Display	Audio
Ex. 1:	RED	Type red

When the student has achieved criterion for each of the three words forming the section, he begins Exercise 2:

	Display	Audio
Ex. 2:	NUT MEN RED	Type red

As in Exercise 2 of the letter strand, the order of the items which comprise the teletype display is random for each presentation. When the student has met criterion for each new word in each of the two exercises, he proceeds to the next section of three words and begins again on Exercise 1.

Strand III - Phonics. When the student has shown mastery of a specified amount of sight vocabulary by completing a predetermined number of sections in Strand II, he begins Strand III with drill and practice in phonics.

Exercise in the phonics strand concentrate on initial and final consonants and medial vowels. A departure is made, however, from traditional phonics exercises in that the students are never required to rehearse or identify consonant or vowel sounds in isolation. The smallest unit of presentation is a dyad, i.e., a single vowel-consonant or consonant-vowel combination.

The following exercises are used in Strand III:

Final Consonant

	Display			Audio
Ex. 1:		-IN		Type /In/ as in pin
Ex. 2:	-IN	-IP	-IT	Type /In/ as in pin
Ex. 3:	-IP	-IN	-IT	
				P--Type pin

Initial Consonant

	Display			Audio
Ex. 1:		CA-		Type /kae/ as in cat
Ex. 2:	CA-	BA-	FA-	Type /kæ / as in cat
Ex. 3:	FA-	BA-	CA-	
				--T Type cat

As in Strands I and II, the student works with a section of three units. He must meet criterion for each set of dyads in the exercise before proceeding to the next set.

The audio reinforces the sound values with randomly selected examples from a matrix of three sample words--two monosyllabic and as often as possible an easily identifiable polysyllabic word. However, the word to be typed by the student in Exercise 3 is always one of the two monosyllabic exemplars.

Strand IV - Spelling Patterns. The spelling pattern strand is designed to provide direct and explicit practice with English spelling patterns and emphasizes the regular grapheme-phoneme correspondences that occur in the graphic representation of English. Although all the spelling patterns presented in this strand were chosen from those taught in the phonics strand, new words are used.

The following exercises are used in the spelling strand:

	Display	Audio
Ex. 1:	CAT	Type cat
Ex. 2:	(no display)	Type cat

A section for this strand consists of three monosyllabic words, such as cat, bat, and rat. These three words embody the same spelling pattern, at, which in each of these words corresponds to the same phoneme, /æt /.

Strand V - Comprehension. When the student has met criterion over a specified number of Strand IV sections, he enters Strand V.

Strand V provides practice on the meaning of the words introduced in the classroom and presented to the student in the sight-word strand. The exercises are of two types: 1) categorization, and 2) phrase and sentence completion. A section in the first exercise consists of three groups of three words. Each word is associated with one of several categories. The presentation consists of a display of the three words followed by a request to type a word of a particular category.

Here is an example:

	Display	Audio
Ex. 1:	HOUSE CAT GREEN	Type the word that is an animal

The order of the three words presented is random and the target word, with its associated category, is randomly chosen from the displayed words. If the program selects "green" as the target word, the audio requests, "Type the word that is a color." "House" generates a request to identify the word "...that is a place." When the student has met criterion in a section of words, he proceeds to Exercise 2.

The second exercise consists of a section of three sentences (or phrases) with one word missing in each. Displayed with each sentence are three words--two are distractors and one correctly completes the sentence. One of the distractors is of the correct form class, but is either semantically or syntactically unacceptable in that it breaks a subcategorization rule (cf. Chomsky, 1965). The second distractor is unacceptable both semantically and syntactically. The format of this exercise is as follows:

	Display			Audio
Ex. 2:	MAD	DRIVE	SWIM	Type the word that correctly completes the sentence
	TIM WILL --- THE CAR			

When a student reaches criterion on Exercise 2 (comprehension sentences), he begins a new section of items in Exercise 1 (comprehension categories). The comprehension strand is unusual in that a section of curriculum items is not carried through all exercises of the strand, but changes with the exercise.

Criteria

There are two types of criteria: one is based on runs of consecutive correct answers to individual items; the other is based on consecutive correct passes through trials (a trial is a set of 3 presentations, one presentation for each item in the current section). There are four criterion counters in each exercise, three of which tally consecutive correct answers for each of the items and one which tallies consecutive correct passes through trials. A wrong answer to a particular item, therefore, will zero the criterion for that item, leave untouched the remaining item criterion counters, and zero the trial criterion counter.

As an example, in the three letters, T, O, and M, criterion might be two consecutive correct answers for each of the letters and one consecutive correct pass through the set of three items. The following protocols of responses would then occur (ignoring the random order of presentation each time):

<u>T O M</u>,	or <u>T O M</u>,	or <u>T O M</u>
c w w	c c c	c w c
c c w	c c c	c c w
c w w		c c c
w c c		
c c c		

TEACHER REPORTS

Efforts have been made to keep this an ungraded program. Although marks exist in a Curriculum Guide to indicate specific levels for comparison or referral by the teacher, no indication is made on the student's print-out of score, percentages or grades.

A complete status report for an entire class is available to a teacher at any time. An example of this report appears in Figure 3. When a status report is requested and the program given a class number, a utility routine prints

CLASS 182 MRS. BRESLIN 7 JAN 70
31 STUDENTS -- BRENTWOOD SCHOOL

READING REPORT -- TYPES + IF RUN TODAY

MIN	L	W	PH	SP	CC	CS			
61.3	6	1	0	0	0	0	+	3023	ANDRE JONES
66.3	17	9	4	4	0	0	+	3232	VIZAR BALCITA
46.6	10	7	2	0	0	0		3233	JEROME BRADFORD
63.8	15	10	4	1	0	0	+	3234	NATHANIEL CHRISTOR
28.1	8	5	1	0	0	0		3235	VERONICA CROWELL
43.0	8	4	0	0	0	0	+	3236	RICO CONTERO
57.2	14	7	2	0	0	0		3237	LINDA FRANCOIS
77.0	15	11	3	2	0	0	+	3238	ALFRED FRAZIER
55.8	11	8	2	0	0	0		3239	RAMON GIL
49.2	13	7	2	0	0	0		3240	KRYSTAL GRIFFIN
56.8	13	5	1	0	0	0	+	3241	MARCUS HENDERSON
23.7	7	3	0	0	0	0		3242	EELITA BARRIES
72.9	16	9	2	0	0	0	+	3243	DWAYNE HOBBS
71.2	14	9	1	0	0	0	+	3244	BARRY JONES
50.6	12	8	2	0	0	0	+	3245	JEANETTE JONES
39.3	9	6	1	0	0	0	+	3246	CURTIS KING
17.1	6	4	0	0	0	0		3247	BETTYE LEWIS
57.0	11	6	1	0	0	0		3248	RICKY LEWIS
31.6	7	5	1	0	0	0		3249	RHONDA PAGE
32.2	6	4	0	0	0	0	+	3251	CHARLES POLLARD
7.4	4	1	0	0	0	0	+	3252	KEITH RICHARDSON
60.9	13	9	5	3	0	0	+	3253	OMAR SORIANO
49.1	10	6	1	0	0	0	+	3254	LANA TERRY
60.6	12	7	3	1	0	0	+	3255	VICTORIA TORRES
49.3	12	6	2	0	0	0	+	3256	BOBBIE VICKERS
61.6	15	9	2	0	0	0		3257	PEYTON WATKINS
38.3	9	5	1	0	0	0	+	3258	YOLANDA WATTS
23.9	8	5	0	0	0	0		3259	TERRY WILKS
0.0	0	0	0	0	0	0		3982	MARIETTA WOMACK
62.9	14	7	2	0	0	0	+	4474	GARY ODLE
0.0	0	0	0	0	0	0		4475	LISA JOSEPH

AVERAGES:

48.8	10	6	1	0	0	0

MINIMUMS:

7.4	4	1	0	0	0	0

MAXIMUMS:

77.0	17	11	5	4	0	0

Figure 3. On-line Utility Program

For Class Information

Reading Program

the date, total number of students in the class, and the name of the teacher. Then the program goes on to list, in this order and for each student who has been "flagged" for reading, the number of minutes accumulated in the reading program, the section number of the curriculum items he is working on in each strand, his identification number, a plus if he was on the program that day, and his name. At the end of the report, as summary statistics, are printed within-class averages, minimums and maximums for accumulated minutes and the strand section numbers.

A report on an individual student is also available to the teacher. See Figure 4 for an illustration of the student's report. When a teacher requests information on a student, the program will provide the student's name, reading class number, the section number and specific items he is working on in each of the five strands, and the total number of minutes he has been on the reading program. At a glance the teacher can note a student's progress in a strand, and the particular items in the exercise. This data gives an accurate, up-to-date evaluation of the student's progress as well as an indication to the teacher of areas in need of reteaching.

HARDWARE

The central processing unit for the reading curriculum, as well as the mathematics, logic, and the Russian program, is a Digital Equipment Corporation PDP-10 computer, which currently has a memory capacity of 196,608 (192 k) 36-bit words and a 1.0 microsecond memory cycle time. This means that it can "fetch" the contents of any one of the 196,608 memory locations in one one-millionth of a second. The PDP-10 is connected to a PDP-8 at the Institute

INDIVIDUAL STUDENT

STUDENT NO: 3232

3232 VIZAR BALCITA

L-17 A V Y

W-9 WATER WARM WAS

PH-4 -IG -IT -IN

SP-4 LOG DOG FROG

CC-0

CS-0

ACC. MIN.: 66.3

Figure 4. On-line Utility Program
For Individual Student
Reading Program

laboratory at Stanford University and is connected by a private high-speed data telephone line to another PDP-8 in the Brentwood Laboratory in the Ravenswood City School District. Although the PDP-8's are computers, they are not used as processors. They monitor the flow of information between the PDP-10 and the student station teletypes. The PDP-8 computers are responsible for character-code conversion, acting as line concentrations and buffers for all teletype information received from and sent to the individual student stations over ordinary telephone lines. The PDP-8 at Brentwood will serve the 14 reading stations at Brentwood, and four terminals at O'Conner school.

Once the audio is recorded, converted to digitized form, and stored on disks, it is accessed in the following way. The PDP-10 retrieves the digital form of an appropriate audio message from its disk storage, places this information in its memory, and informs the audio multiplexer that it has an audio message to be passed on to a particular student station. The multiplexer then takes the digital audio from the PDP-10 and passes it on, 36 bits at a time, to the shift register assigned to the student station which requires the audio message. The station's shift register will, in turn, hand the digital audio, one bit at a time, to the station's digital analog converter which will convert the audio to analog form and send it over an ordinary telephone line to the appropriate student station. The function of the multiplexer in monitoring the audio information is somewhat analogous to the function of the PDP-8's, which monitor the teletype information. Therefore, the primary function of the multiplexer is to monitor and store information so that it will be immediately available to any one of the 40 student stations.

THE READING PROGRAM AS AN EXPERIMENTAL TOOL

It would be impossible to list all the experimental possibilities of this system. By way of summary, we present the following parameters which can easily be set for experimental or pedagogical purposes for entire classes or for individual students.

1) The amount of time to be spent on the machine in any one session. (The default value is 8 minutes.)

2) The amount of time to be spent in each of the 5 strands before branching to the next. (The default value is 2 minutes for each strand.)

3) The probability with which a correct answer reinforcing audio message is to follow a correct response in each exercise. (The default value is .33 for every exercise except those of the readiness strand in which it is .50.)

4) The section number of the curriculum items a student is to be working on in each strand. (The default value for each of these is 1 and is incremented as the student achieves criterion with successive sections of curriculum items.)

5) The number of sections to be completed in each strand before initial entry into the next strand. (The default values are: 4 sections of letters before beginning the word strand, 5 sections of words before beginning the phonics strand, 3 sections of phonics before beginning the spelling strand, 6 sections of spelling before beginning the comprehension strand.)

6) The item criterion that must be achieved in each exercise. (The default value for all exercises is 2 consecutive correct answers to an item.)

7) The trial criterion that must be achieved in each exercise. (The default value for all exercises is 1 correct pass through a trial, i.e., correct on all 3 presentations in the trial.)

8) The order of the curriculum items presented in each strand. This variable consists of a large vector of curriculum item numbers and for this reason must be controlled directly by the reading program driver rather than processed from the 200-word student restart record.

It is also possible to write entire experiments either as subroutines or as co-routines for the reading program and branch to them as if they were simply additional strands. This capability allows a student to be branched into and out of experimental situations which appear to him as nothing more than standard facets of his daily run.

PRELIMINARY EVALUATION

As a major first step in evaluating this curriculum, a full program of testing will be undertaken in May of this year. Both the Stanford Achievement Test and a test more directly concerned with psycholinguistic skills* will be administered to three groups of first and second grade pupils: those who have had CAI reading, those who have had CAI math only, and those who have had no computer-assisted instruction. Already, however, there are some preliminary results concerning the effectiveness of the reading program.

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*Designed by Ruth N. Hartley, formerly of the Institute for Mathematical Studies in the Social Sciences, currently assistant professor and Director of the Remedial Reading Laboratory, University of California, Santa Barbara.

In May, 1969, the Ravenswood School District administered the Metropolitan Readiness Tests (MRT) to its kindergarten students and in November, before CAI reading was begun in the district, the reading project staff administered the MRT to about 450 first grade students. From this data it was possible to match, on the basis of the May MRT scores, 20 boys and 22 girls, half of whom (the experimental group) had accumulated about three months exposure to CAI reading in the spring and summer of 1969 and half of whom (the control group) had completed kindergarten and the special summer session with no exposure to CAI reading. The mean MRT score gain of the 10 experimental group boys was 12.50, as opposed to a mean gain of 7.00 for the 10 control group boys. The mean MRT score gain of the 11 experimental group girls was 9.18, as opposed to a mean gain of 5.00 for the 11 control group girls. Overall, the MRT performance of the experimental group (N = 21) improved significantly more than that of the control group (N = 21), $t = 3.16$, $p < .01$. It should be noted that the November post-test was administered four months after the last exposure of the experimental group to CAI reading. These results are presented in Table 1.

It is interesting to note that the improvement in average gain for experimental over control boys (5.50) is greater than the improvement in average gain for experimental over control girls (4.18). This result is similar to that of Atkinson (1968) who also obtained greater performance gains by boys than by girls in a CAI initial reading program. This result opposes the usual expectancy of superior performance gains by girls than by boys in initial reading.

THREE UNSUPPORTABLE CONCLUSIONS

After five years of experience with computer-assisted instruction in initial reading, we should have reached some conclusions which are worth bringing to the

Table 1*

	Experimental group (N=21)			Control group (N=21)		
	Average pretest score	Average post-test score	Average gain	Average pretest score	Average post-test score	Average gain
Boys	44.60	57.10	12.50	45.30	52.30	7.00
Girls	45.64	54.82	9.18	44.55	49.55	5.00
Combined	45.14	55.90	10.76	44.90	50.86	5.95

*Because of limitations of time and money, the numbers subtest and the supplementary draw-a-man subtest were not given; consequently, the means in this table represent scores from only 5 of the 7 MRT subtests.

attention of educators. The following three conclusions are unsupportable in that they come to us not empirically from our research but from our experience with what works and what does not.

1) For a time, the philosophy in CAI seemed to be the more hardware (image projectors, light pens, cathode ray tubes, etc.), the better. We believed we could take all the hardware we could get and then some. The major lesson we have learned in the last five years is that of simplicity. We have learned the utility of attempting only what we can do well (and inexpensively) and of building on that. From an experimental or pedagogical standpoint, our Model 33 teletypes with digitized audio comprise rich enough instructional terminals to occupy our efforts for some period of time.

2) Having developed language-related CAI programs which necessarily state behavioral objectives on a second to second basis, we are of the opinion that behavioral objectives alone cannot and should not comprise all the goals of a curriculum. A large portion of what we mean by the teaching of any given subject is simply not expressible in behavioral terms. Vague remarks about behavioral goals can be made but we doubt that they are addressed to the central problem of instruction in reading. We believe that the whole of reading cannot be taught efficiently by computer and that the role of the teacher becomes essential precisely where behavioral objectives leave off.

3) One argument that often comes up is that the last thing culturally deprived children need is less contact with human beings. We claim that exactly the opposite may be true. It may be that it is precisely those social-psychological variables which are so prevalent in the classroom and which computers

generally lack that makes classroom learning so difficult for these children. We believe that for many aspects of the cognitive domain, computers, with their absolute imperturbability and objectivity, represent the best means of reaching these children.

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